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EXPERIMENTAL ANALYSIS OF REINFORCER HIERARCHIES IN DEVELOPMENTAL RETARDATES--BASELINE STABLIZATION.

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THE FIRST STAGE OF A RESEARCH PROJECT INVESTIGATING REINFORCER PREFERENCES IN DEVELOPMENTAL RETARDATES IS DESCRIBED. THE SUBJECTS, 12 MALES AND THREE FEMALES (CHRONOLOGICAL AGE 10 TO 22, MENTAL AGE 2.8 TO 8.7), WERE PRESENTED WITH A TASK IN WHICH 35MM COLOR SLIDES WERE PROJECTED ONTO A CONSOLE WINDOW. RESPONSES REQUIRED SUBJECTS TO CHOOSE AMONG FOUR REINFORCERS--M/M CANDIES, CHEERIOS, TRINKETS, AND PENNIES. RESULTS INDICATED THAT MOST SUBJECTS TENDED TO DISTRIBUTE THEIR REINFORCER CHOICE RESPONSES IN ONE OF TWO WAYS--(1) CHOICES WERE INITIALLY DISTRIBUTED OVER THE FOUR REINFORCERS, AND WITHIN SIX SESSIONS ONE REINFORCER BECAME MORE FREQUENTLY SELECTED AND (2) A PARTICULAR REINFORCER WAS INITIALLY SELECTED WITH HIGH FREQUENCY, AND A SECOND REINFORCER DEVELOPED AS A LOW FREQUENCY CHOICE. OTHER RESPONSE PATTERNS WERE ALTERNATION ON A CYCLICAL BASIS AND VARIABILITY OF CHOICE NOT BECOMING STABLE UNTIL THE 25TH SESSION. FURTHER REFINEMENT OF METHODOLOGY IS INDICATED. EIGHTEEN GRAPHS AND FOUR REFERENCES ARE INCLUDED. (DT)

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GEORGE PEABODY COLLEGE FOR TEACHERS/NASHVILLE, TENNESSEE 37203

# Experimental Analysis of Reinforcer Hierarchies in Developmental Retardates: Baseline Stabilization

by

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THIS IS A WORKING REPORT ON THE FIRST STAGE OF A RESEARCH PROJECT IN THE EXPERIMENTAL ANALYSIS OF REINFORCER HIERARCHIES IN DEVELOPMENTAL RETARDATES. DATA AND DISCUSSION ARE RESTRICTED TO THE DEVELOPMENT OF A METHODOLOGY, AND SHOULD NOT BE INTERPRETED AS ANALYSIS OF REINFORCER HIERARCHY OR ITS PARAMETERS.

# THE EXPERIMENTAL ANALYSIS OF REINFORCER HIERARCHIES IN DEVELOPMENTAL RETARDATES: BASELINE STABILIZATION

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The behavior of an individual is viewed as the product of a continuous interaction between the individual and his environment. At any point in time, behavior is viewed as the product of the interaction between current environmental factors and the behavioral characteristics of the individual. Among the environmental factors which operate on behavior, reinforcement, the consequence of behavior, is prominent.

Although differences between individuals with respect to effective reinforcement consequences are recognized, it frequently is assumed that specific reinforcing events maintain their effectiveness for a given individual over a long period of time. It further is assumed that there generally is a high degree of congruence between the kinds of effective reinforcers for an individual and the reinforcers present in the environment. It appears that data bearing on these assumptions are necessary for a more adequate understanding of factors influencing the interactions between behavior and the environment.

Knowledge of these factors particularly is important in the case of retarded individuals. It frequently is noted that the retardate's behavior is unusually impervious to those environmental consequences generally effective as reinforcers for the majority of individuals. Some of the slow learning and maladaptive behavior of the retardate may be accounted for by this imperviousness, the instability of events as effective reinforcers, or the lack of congruence between environmental events and those which are functionally effective for the specific retardate.

The first problem encountered in the assessment of the relative effectiveness of a set of reinforcing events is the development of a methodology which meets the following criteria: unconfounded evaluation of a number of reinforcing events concurrently; reliability of assessment over repeated measures; and sufficient stability and sensitivity to permit classification and parameter analysis within individual subjects. The usual method has been that of the paired comparisons approach, in which individual subjects are asked to select one reinforcer in each of all possible pairings of a set of reinforcers (Schutz & Naumoff, 1964; Tyrrell, Witryol, & Silverg, 1963; Witryol & Fischer, 1960). Although repeated

measures with individual subjects are feasible (Tyrrell, et al, 1963), the period of time over which measures have been taken appears to be of insufficient duration to permit the evaluation of long-term changes in the behavior. Further, choice responses are made in pairs and although the methodology provides for comparisons of behavior with all possible pairs, at no time is the behavior sampled with all reinforcers in the set available. In view of the fact that individuals do not experience the delivery of the selected reinforcer as a consequence of their choice, it is difficult to assess what the consequence of choice is, and what effect it has on choice behavior.

The first objective of this research program was to develop a methodology for reliable and repeated assessment of the ranking of the relative effectiveness (by means of choice-response data) within a specific set of events for individual subjects. Events were chosen which were both representative of those usually found to be reinforcing for members of the retarded population (M & Ms, Cheerios, trinkets and pennies) and representative of three major classes of tangible events (consumables, manipulables and generalized reinforcers). The procedure was so designed that each subject is afforded repeated opportunities to select and receive one of the reinforcers, from an array of all four.

The second objective was to obtain information on the organization and long-term stability of the choice behavior of a small sample of retarded individuals under these conditions. The third was to obtain information about the methodology itself, in order to develop a methodology which meets the criteria previously enumerated and provides a baseline behavior appropriate for the analysis of the parameters of reinforcer hierarchy and the relationships between these parameters and the acquisition and maintenance of complex behaviors.

## METHOD

### Subjects

Subjects were residents of a state institution for the retarded[1]. Fifteen individuals, 12 males and three females, were selected from the

[1]Clover Bottom Hospital and School, Donelson, Tenn., George L. Wadsworth, M.D., Superintendent.

population who met the following criteria: no gross sensory-motor handicaps; no severe behavioral problems; no history of chronic illness; MA two or more yrs and CA 10 to 25 yrs. The MA range of Ss was 2.75 to 8.67 yrs, mean 5.38 yrs, and the CA range was 10 to 22 yrs, mean 15 yrs.

## Apparatus

The apparatus was a modification of the multiple-choice visual discrimination apparatus described in detail by Hively (1964). It consisted of a large, wall-mounted console, on the face of which were one large, rectangular window and, below, four smaller windows. Stimuli were rear-projected onto these windows which were connected to micro-switches. Pressure on any window resulted in micro-switch closure. A reinforcer receptacle was located at the lower right-hand corner of the console, and each delivery of a reinforcer was accompanied by a 3-sec illumination of the receptacle and the simultaneous operation of a buzzer.

The console was located in a sound-attenuated room containing two chairs, a one-way observation window and an intercom for auditory monitoring. Fully automated programming and recording apparatus were located in an adjoining control room.

Stimuli were 35 mm color transparencies projected on the console windows. Two types of stimuli were presented alternately; one projected green light onto all five windows (access stimulus) and the other projected pictures of the four reinforcers (M & Ms, Cheerios, trinkets and pennies), with a different reinforcer pictured on each of the smaller windows. Positions of the reinforcers varied from slide to slide.

## Procedure

Subjects were seen individually one to three times weekly. They were led from the laboratory waiting room by E with the instruction, "Come with me," and brought into the experimental room. In the first session, E stood to the left of the console, instructed S to sit in the chair in front of the console, and said, "Watch me." With the access stimulus (green light) on, E made three, discrete, paced responses on the larger (access) window which were followed by removal of the access

stimulus and the presentation of the choice stimulus (one of the 24 possible arrangements of the reinforcer pictures). The S was instructed, "Get whatever you want," and if he failed to respond appropriately on one of the choice windows within approximately 5 sec, the instruction was repeated. Subjects who failed to respond with two repetitions of the instruction were told, "Push on the one you want." Two consecutive responses on one of the choice windows were required. If S failed to emit two consecutive responses, the instruction to "Push on the one you want" was repeated. None of the Ss failed to respond under these instructions.

Following the emission of two consecutive responses on one window, one unit of the reinforcer pictured there was delivered, the choice stimulus was removed and the access stimulus was re-presented. The S then was instructed, "Now you do it," and all Ss made three responses on the access window. In some cases, it was necessary for E to point to the access window before S would respond. The E remained until S emitted one complete access-choice response chain without assistance, leaving with the instruction, "Get whatever you want, and I'll be back when it's time to leave."

Stimuli were programmed on a chain mult FR 3 FR 2 schedule, with three access and two choice responses, in sequence, required in the presence of the appropriate stimuli before a reinforcer was delivered. Simultaneous responding on two or more windows was not reinforced, nor were alternating choice responses (one response on one choice window followed by one on another) nor operation of the choice windows in the presence of the access stimulus.

The ratio on the choice response was changed from FR 2 to FR 3 when S emitted the second response within 5 sec of the first for five consecutive choice trials, and did not alternate choice responses during any trial. Similar criteria were applied to access responses, and the access ratio was adjusted over the first three sessions to that value which resulted in each S receiving no more than 100 reinforcers per session; the access ratio remained fixed at that value for the remainder of the baseline sessions. Session length was fixed at 30 min in order to obtain a reliable sample of behavior within each session, and the maximum number of reinforcers established as 100 to avoid reinforcer satiation.

At the beginning of the second and all subsequent sessions, E led S to the experimental room saying, "Come with me." The E left at the door to the room with the instruction, "Get whatever you want, and I'll be back when it's time to leave." At the end of each session, E re-entered the room and said, "That's all for today." If necessary, E remained with S while reinforcers were put into a small bag which had been put in the reinforcer receptacle before the beginning of the session.

## RESULTS

Over the first six sessions, Ss tend to distribute their reinforcer choice responses in one of two ways. A common pattern is one in which choices are distributed over the four reinforcers, with no clear preferences discernible. Within approximately six sessions, one reinforcer becomes more frequently selected, with the others decreasing to near-zero frequency or selected occasionally in some cyclical fashion. Figure 1 is an example of this type of distribution. Initially, choices are distributed over the four reinforcers, and the pattern of choices varies from one session to the next. By the fifth session, two trends may be observed - pennies are being selected with increasing frequency and there is a sharp decrease in the number of M & M choices. Subsequently, there is a systematic alternation of penny and M & M choices, with a maximum of approximately 25 M & Ms selected in any session.

Figure 2 presents the same data plotted in terms of the per cent of total reinforcer choices per session; this describes relative choice behavior independently of the total number of reinforcers obtained. The same pattern may be noted - pennies are selected on approximately 75 to 100 per cent of the occasions when a choice may be made, and M & Ms are selected on an alternate session basis, with no more than 23 per cent of choices being M & M during a given session. When plotted independently of day-to-day variation in rate (the number of choice responses made per session), the data show a greater stability with respect to the distribution of choices over sessions. The cyclical nature of the distribution remains evident.

A somewhat different picture may be seen in Figure 3. In this case,

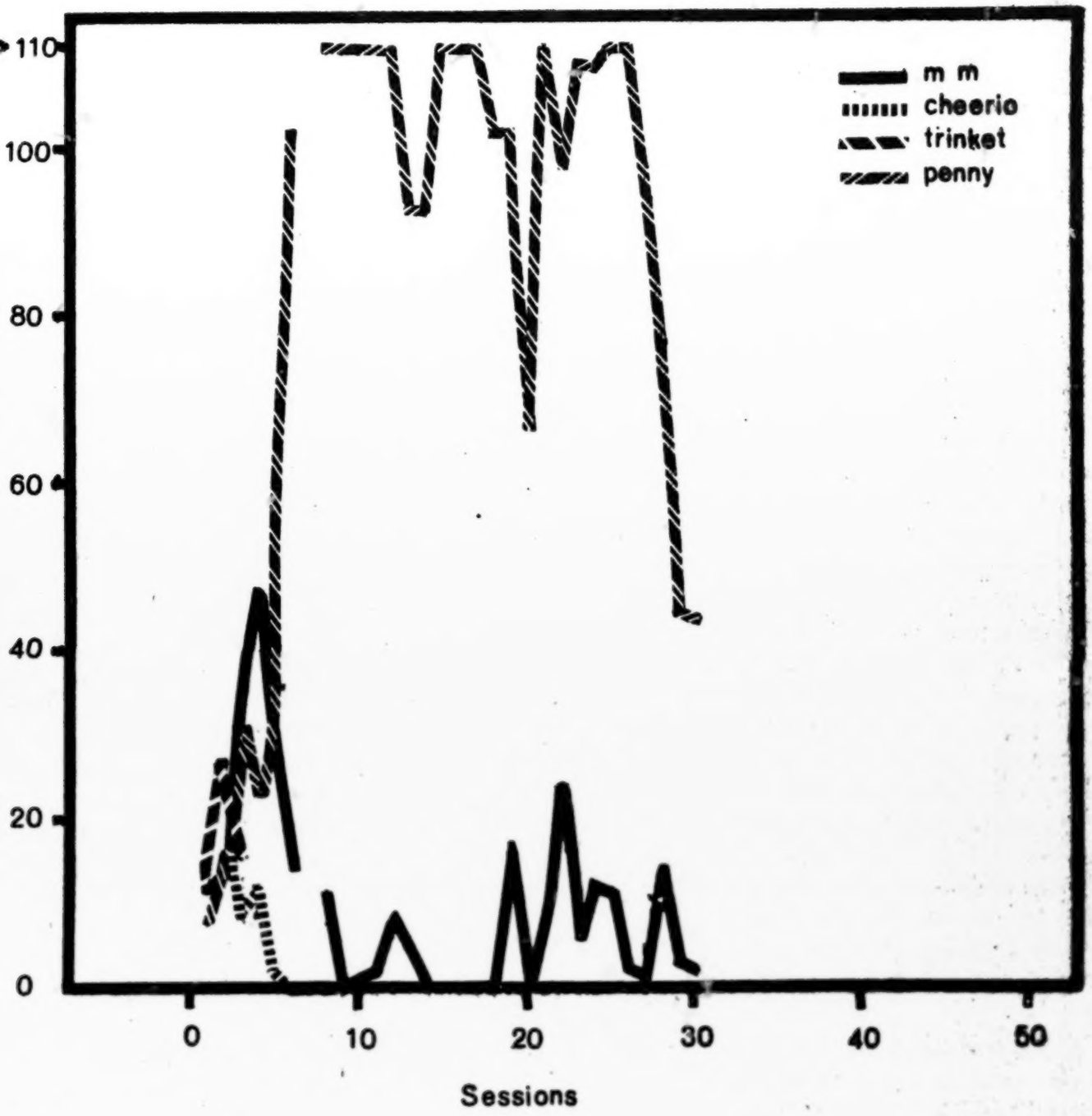


Fig. 1. Frequency of reinforcer choices per session, S N.

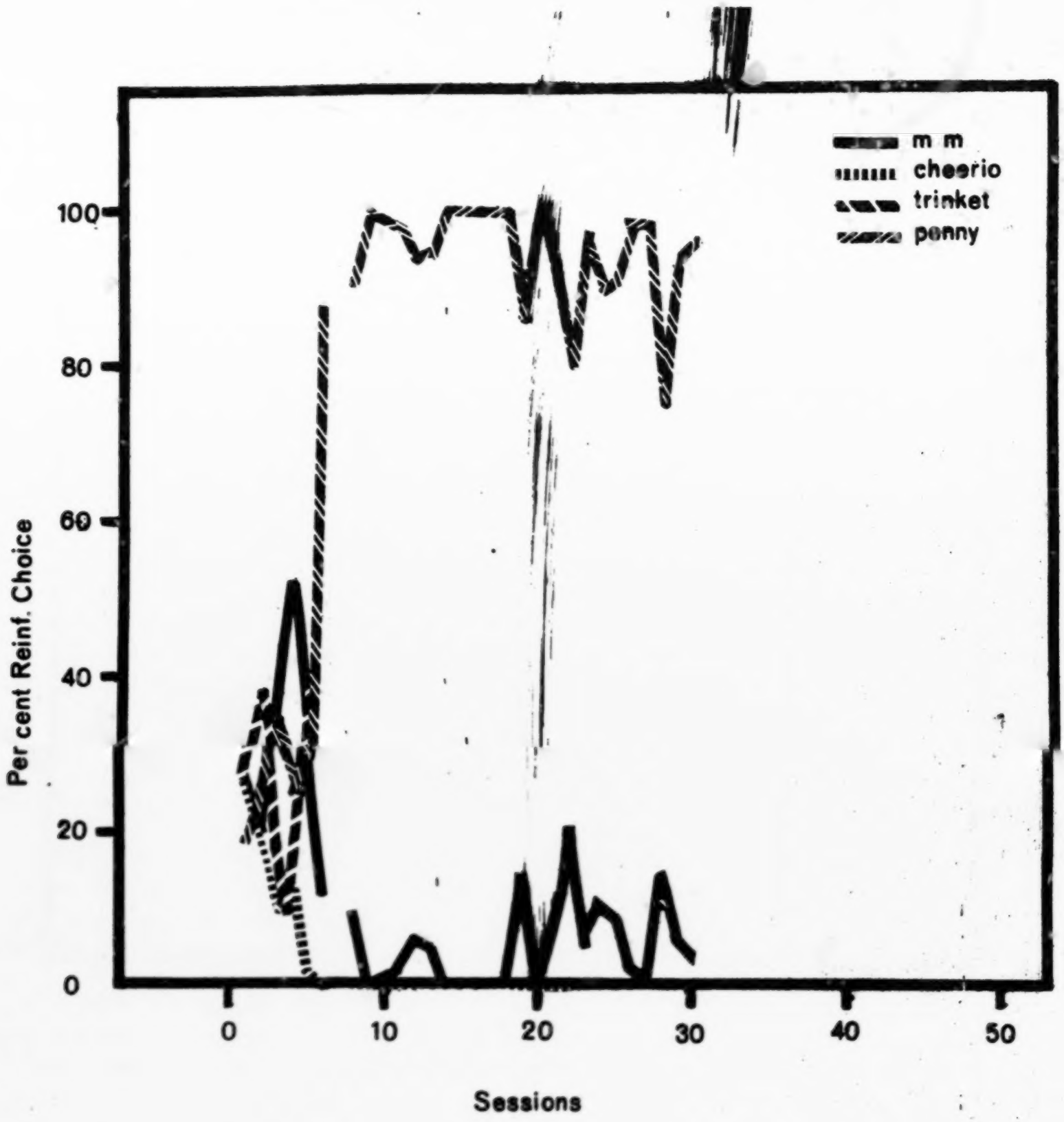


Fig. 2. Per cent reinforcer choices per session, S N.

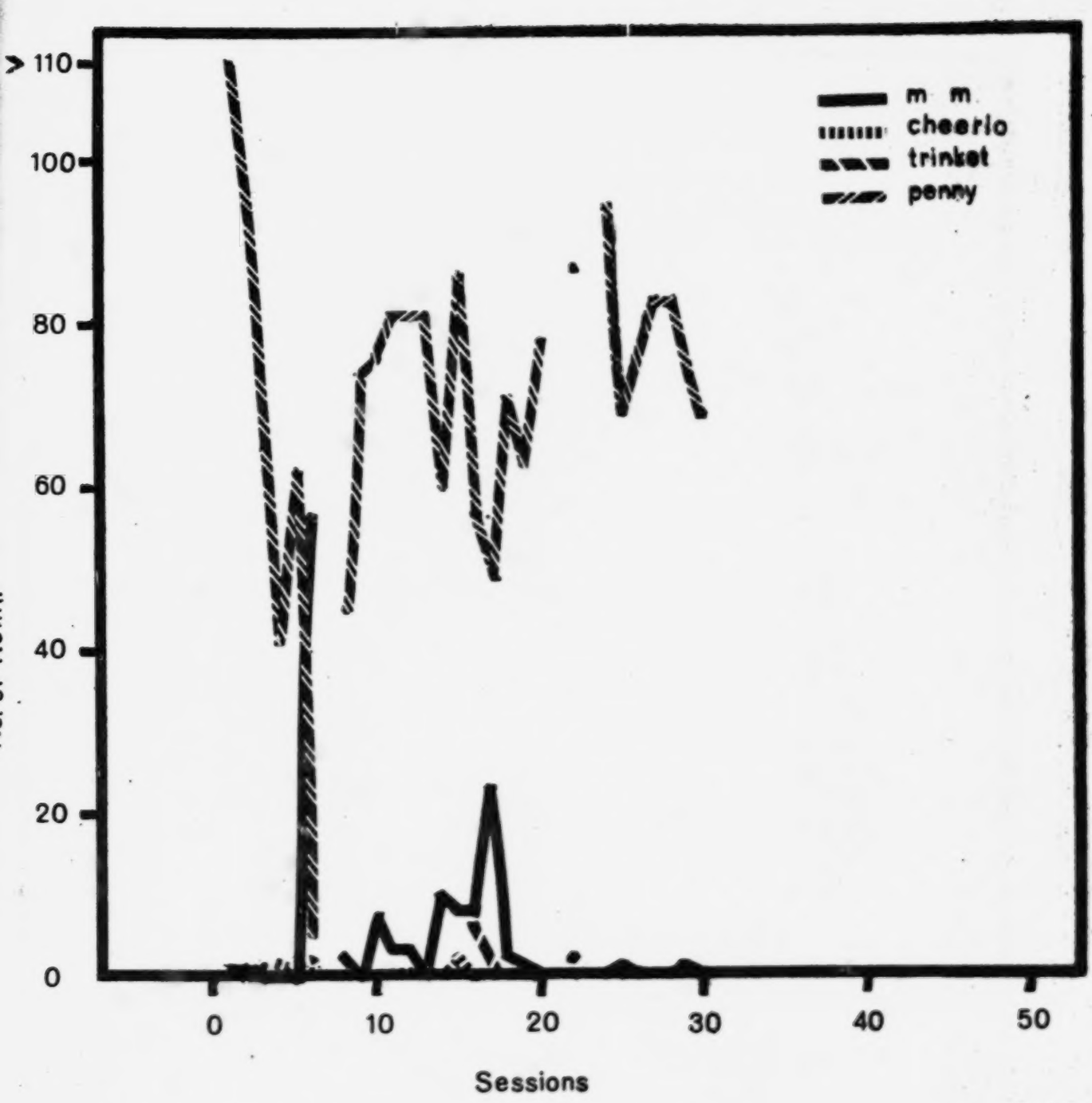


Fig. 3. Frequency of reinforcer choices per session, S W1.

one reinforcer, pennies, was selected at every opportunity during the first session, and it was not until the sixth session that another reinforcer, M & Ms, was selected. Over these sessions, the total number of reinforcer choice responses made underwent a decrease as a function of manipulation of the access ratio. Rate then shows some leveling and the pattern of high frequency of selection of pennies with some alternation between low and zero frequency of M & M selection may be observed. This no longer may be seen after some 20 sessions.

The same data are presented in Figure 4, and the same transition in behavior over the first few sessions may be noted. By the twentieth session, the distribution clearly has stabilized, with pennies being selected some 98 to 100 per cent of the time for 10 successive sessions.

Another example of this type of distribution is shown in Figures 5 and 6. For the first seven sessions, only pennies were selected. As in the previous examples, a second reinforcer, in this case M & Ms, starts being selected with a relatively very low frequency, and there is some regular variation in this frequency from session to session.

The second common type of distribution, then, is one which is characterized by a high frequency of selection of a particular reinforcer from the first session. A second reinforcer then develops as a low frequency choice, and there is a systematic, cyclic pattern to the selection of this reinforcer, usually an alternate day pattern. Figures 7 and 8 are another example of this sort of distribution pattern.

In the previous examples, cyclical changes in the choice responses have been regular, but have involved low-frequency behavior superimposed on extremely regular high-frequency behavior. These examples may be characterized as instances of a stable and high preference for a particular reinforcer, with some form of alternating, low-frequency choice of a second reinforcer. Other subjects show far greater cyclicity. Figure 9 shows the behavior of an individual who for several sessions showed approximately the same frequency of choice for two reinforcers (M & Ms and pennies) and a regular, session-to-session alternation between these two. By the 27th session, the cyclicity remains strongly evident, but the frequency with which each reinforcer is selected shows marked change - the frequency of one (M & M) varies from zero to approximately 30, while the frequency of the other (penny) varies from

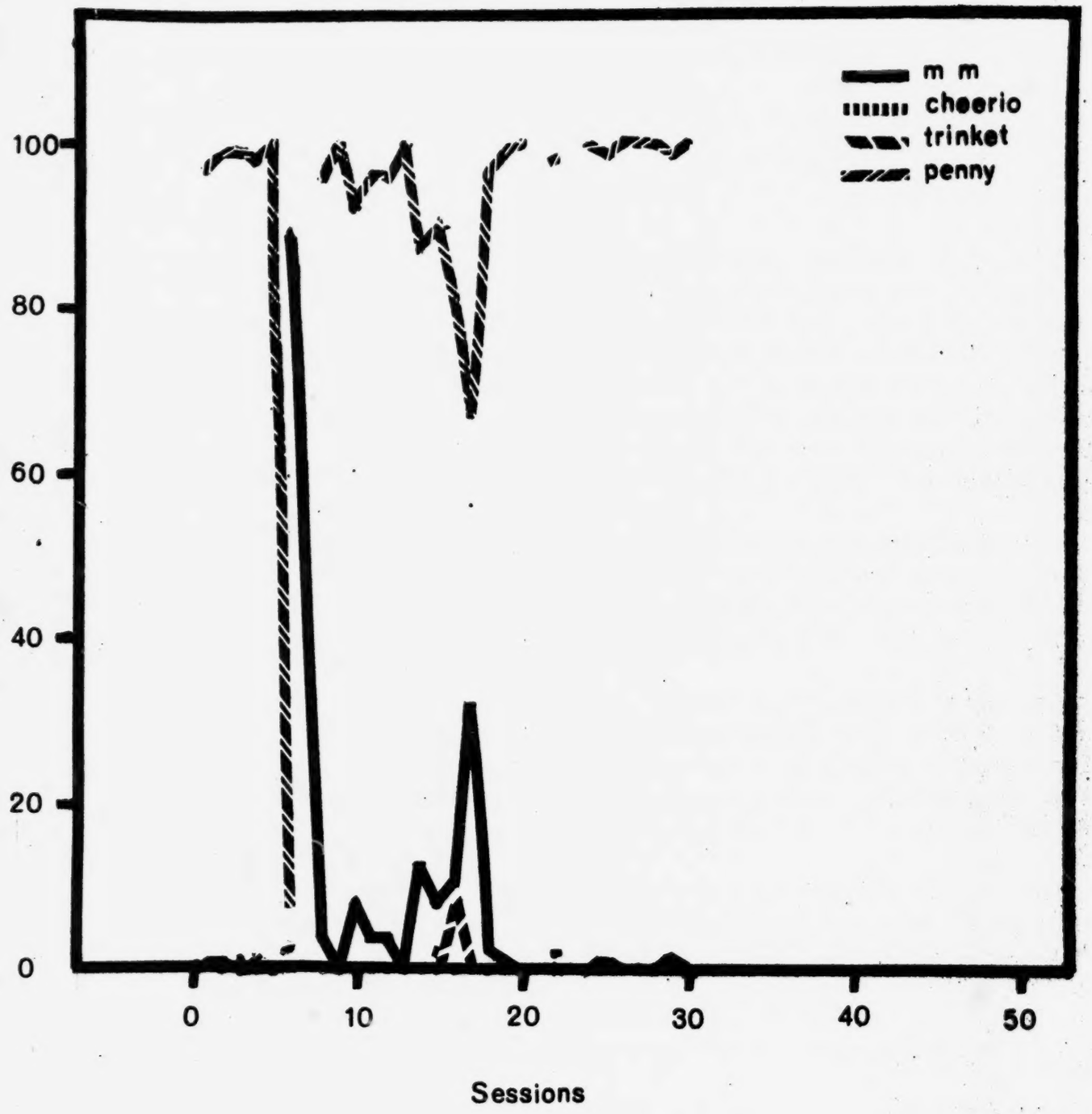


Fig. 4. Per cent reinforcer choices per session, S W1.

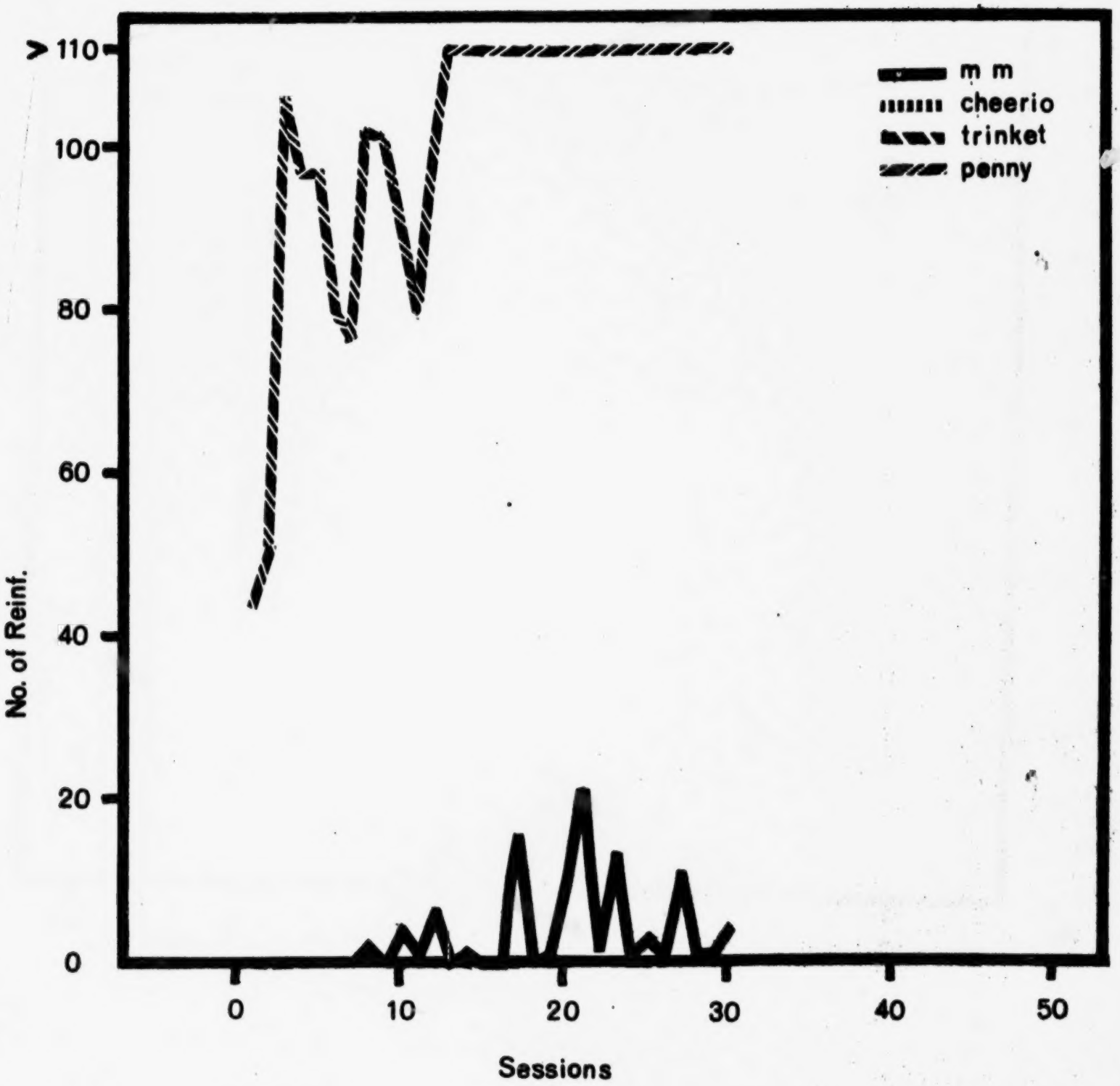


Fig. 5. Frequency of reinforcer choices per session, S J.

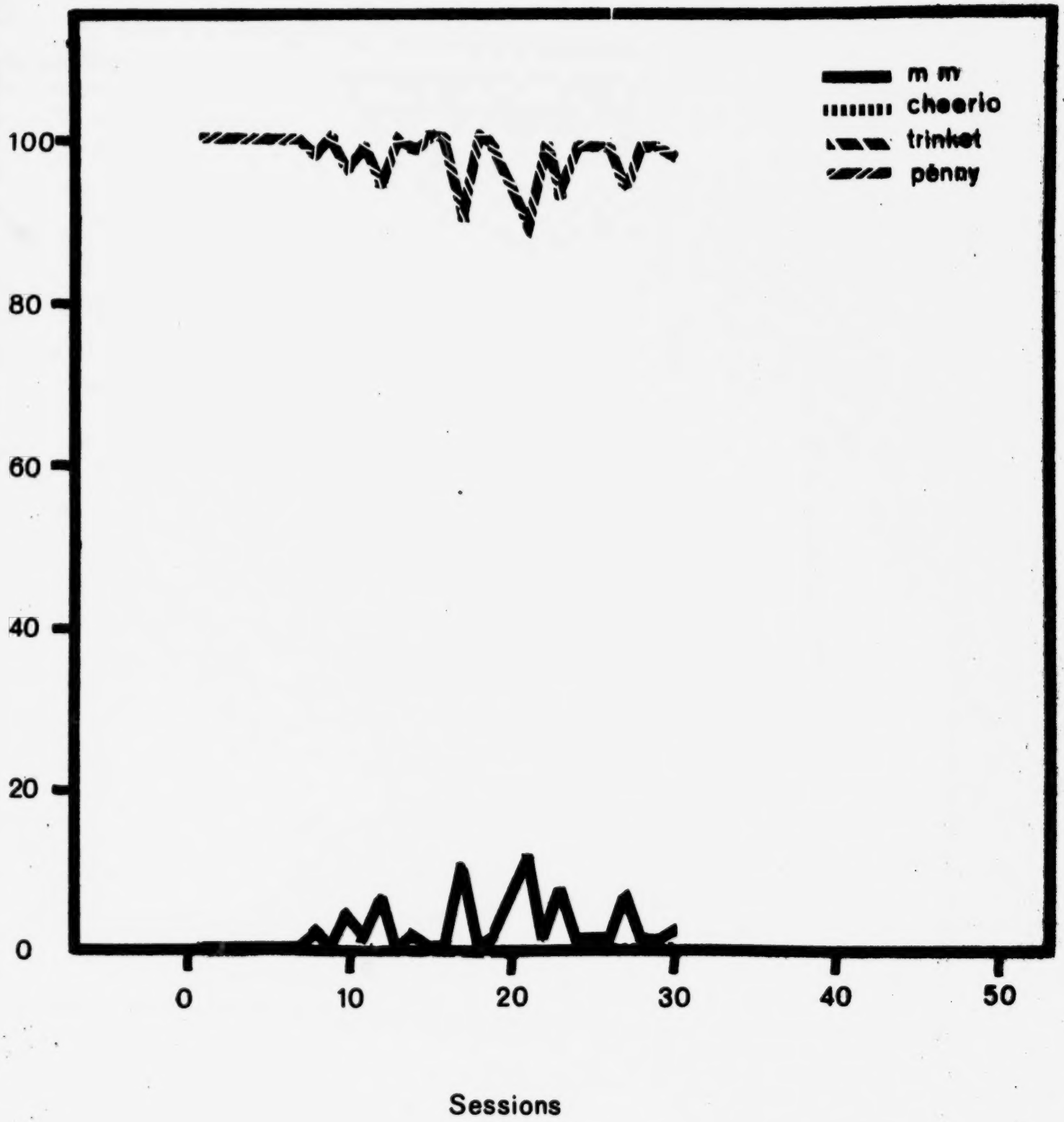


Fig. 6. Per cent reinforcer choices per session, S J.

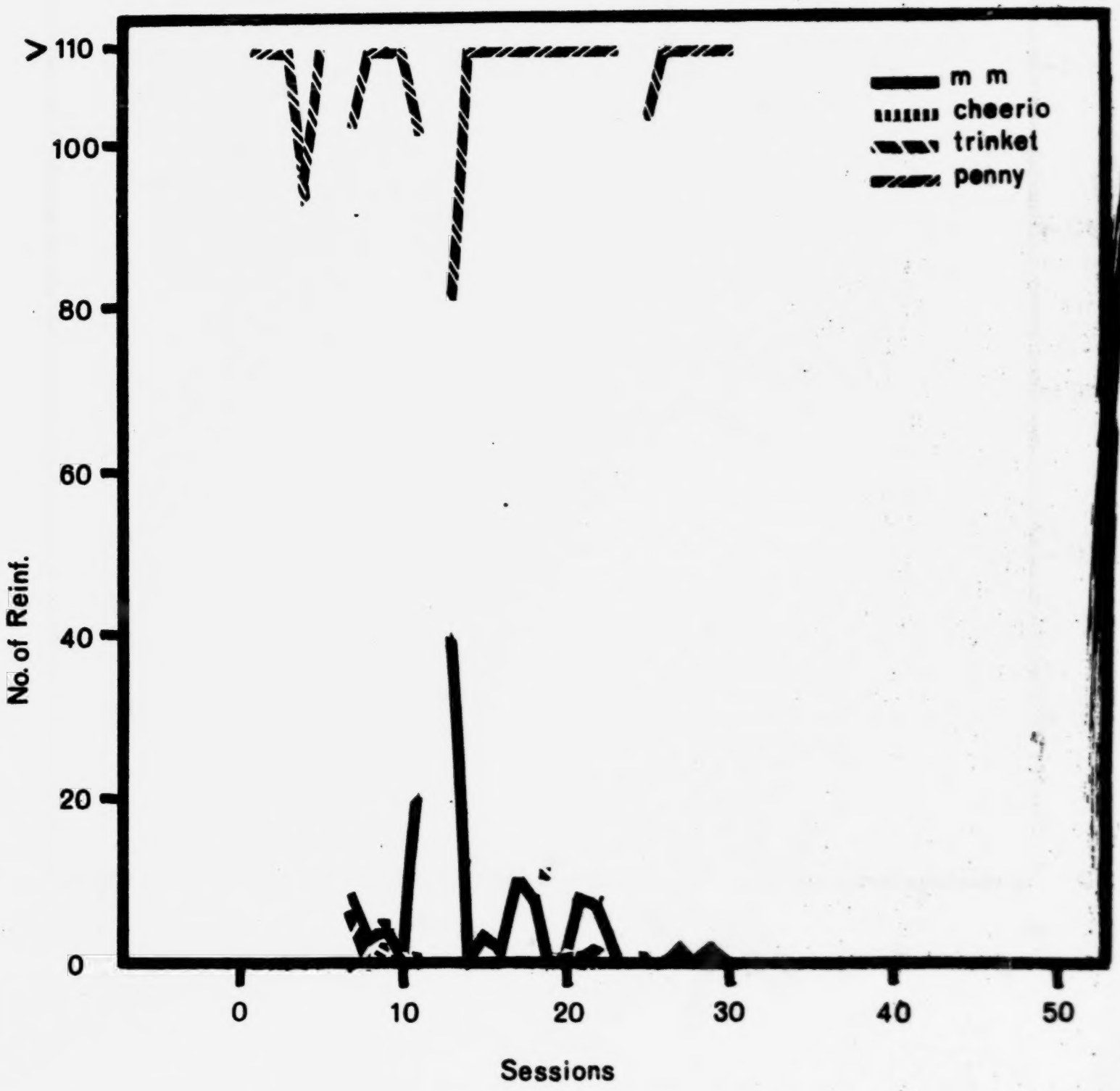


Fig. 7. Frequency of reinforcer choices per session, S B.

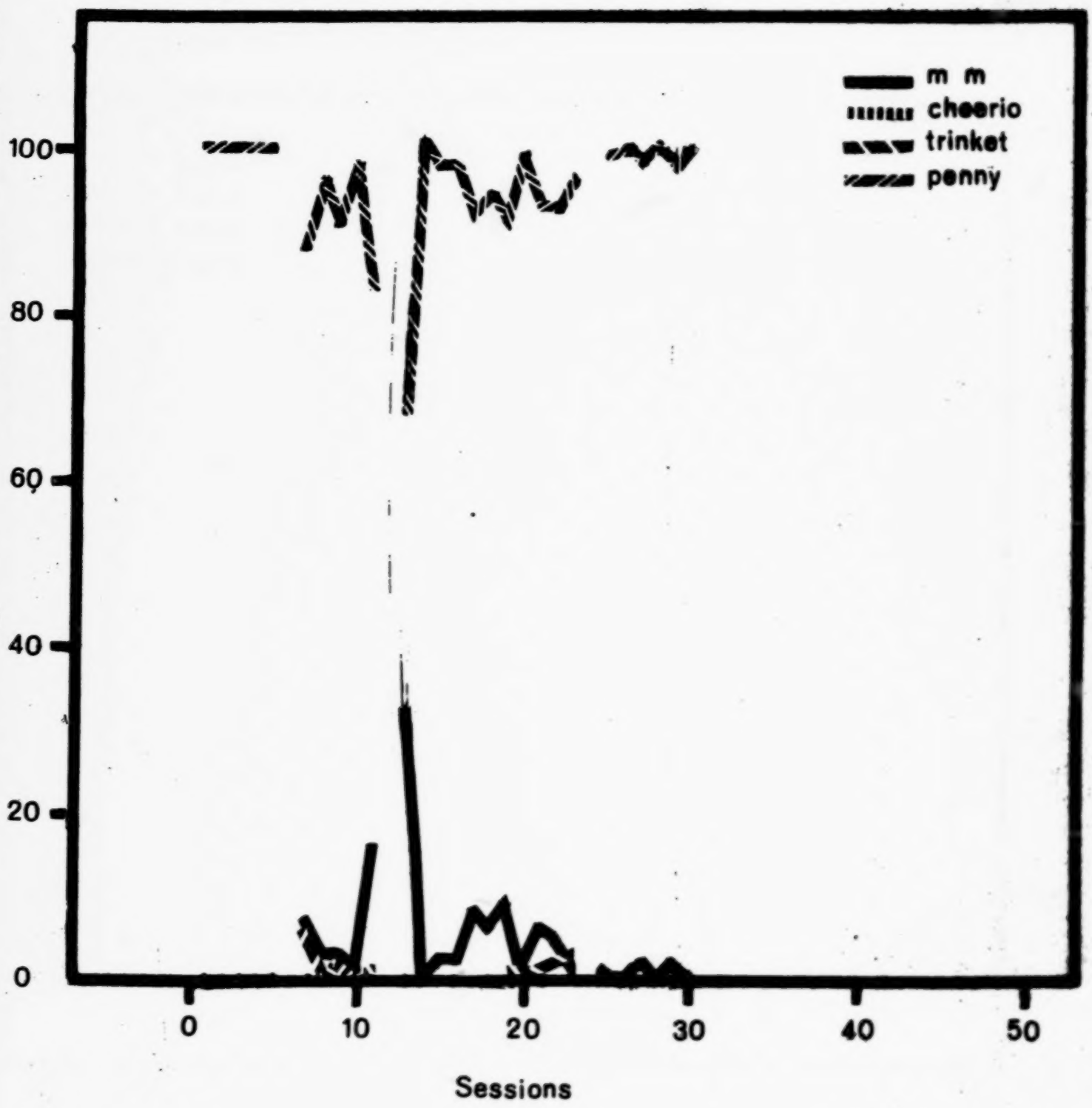


Fig. 8. Per cent reinforcer choices per session, S B.

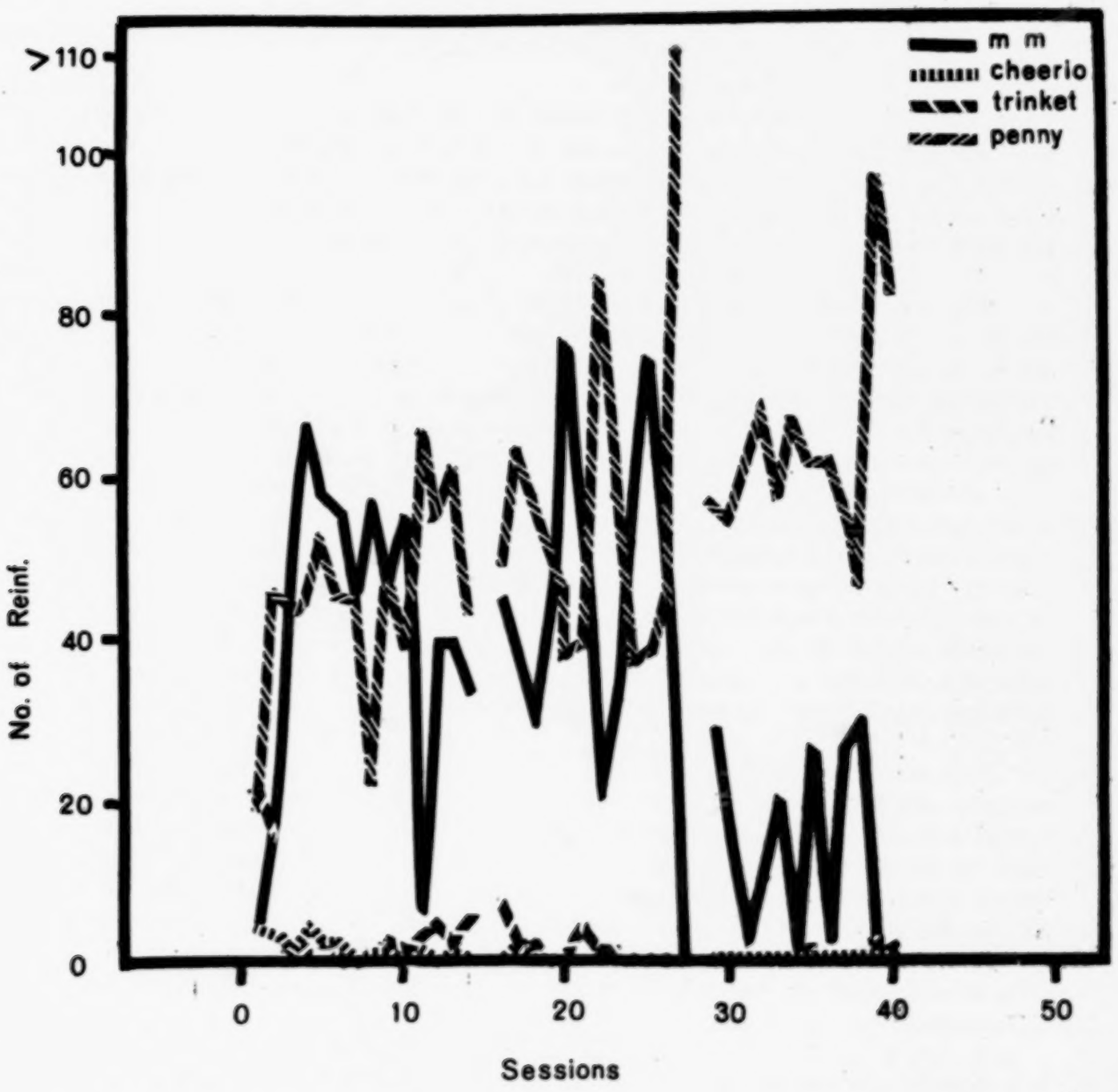


Fig. 9. Frequency of reinforcer choices per session, S Gl.

50 to 100. The cyclic variability remains, but there no longer is any overlap between the two frequencies, and the behavior may be said to be developing a high degree of stability with respect to a clear "preference" for a particular reinforcer. The same trend may be observed in Figure 10, per cent of reinforcer choices independent of overall rate of choice responses.

Figures 11 and 12 are another example of this type of behavior. Here, there is both session-to-session alternation between two reinforcers (M & Ms and pennies), and a cyclic phenomenon with a third reinforcer (Cheerios) which developed over a long period of time. Cheerios were selected some 50 times early in the series of sessions and there was a gradual decrease to a level of approximately 10 to 15 selections per session for 20 successive sessions. By about the thirty-fourth session, the frequency had increased to a level of approximately 65 choices, and again was followed by a decrease in frequency. At this point, the data indicate that the leveling point may be somewhat higher than previously. In view of the fact that overall rate also appears to be undergoing a systematic decrease, this, in part, may account for the current level. However, when the data are examined with some control for rate, Figure 12, the leveling at a higher value still seems evident.

Figures 13 and 14 also are examples of cyclicity and a tendency for overall rate to decrease over a number of sessions. In this case, behavior which seemed to be fairly well distributed over three reinforcers for the first 20 sessions shows the partial breakdown of the distribution. What was a clear separation of pennies, 60 to 110 per session, M & Ms, 15 to 50 per session, and Cheerios, zero to 5 per session, no longer is evident in the data from the last 20 of a total of 40 sessions. Again, an overall rate of reinforcer choice responses is correlated with this change in the distribution of choice responses.

Finally, there is a small number of Ss who show some indications of a stable distribution only after many sessions. An example of this may be seen in Figures 15 and 16. In this instance, variability from session to session is high, with some sort of clear distribution possibly to be seen by the twenty-fifth session. However, it is not clear whether this represents the beginning of a stable high-frequency selection of trinkets that will continue, or whether it is comparable to the distribution as it appears around the fifteenth session, a short-term separation which was followed

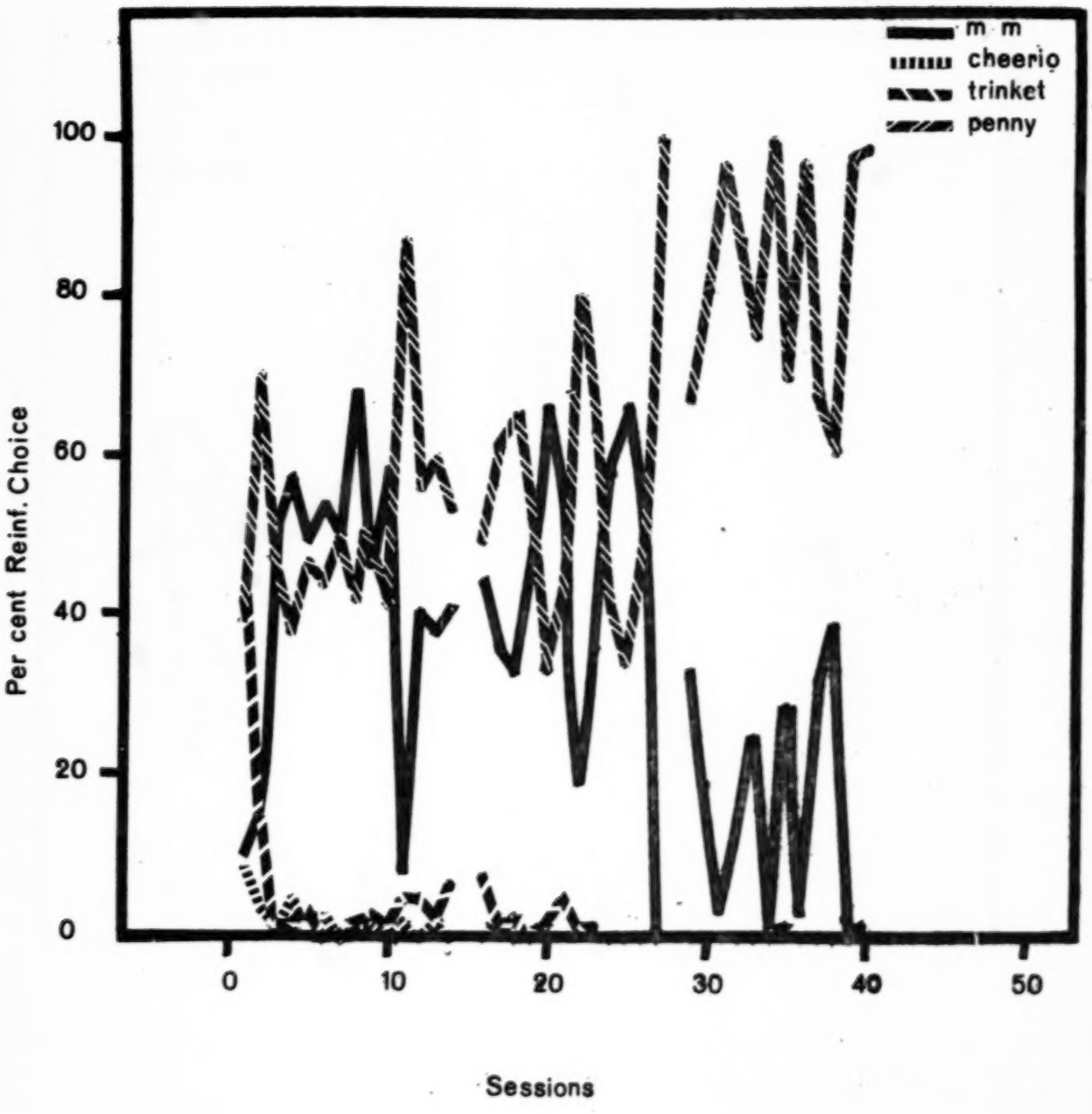


Fig. 10. Per cent reinforcer choices per session, S G1.

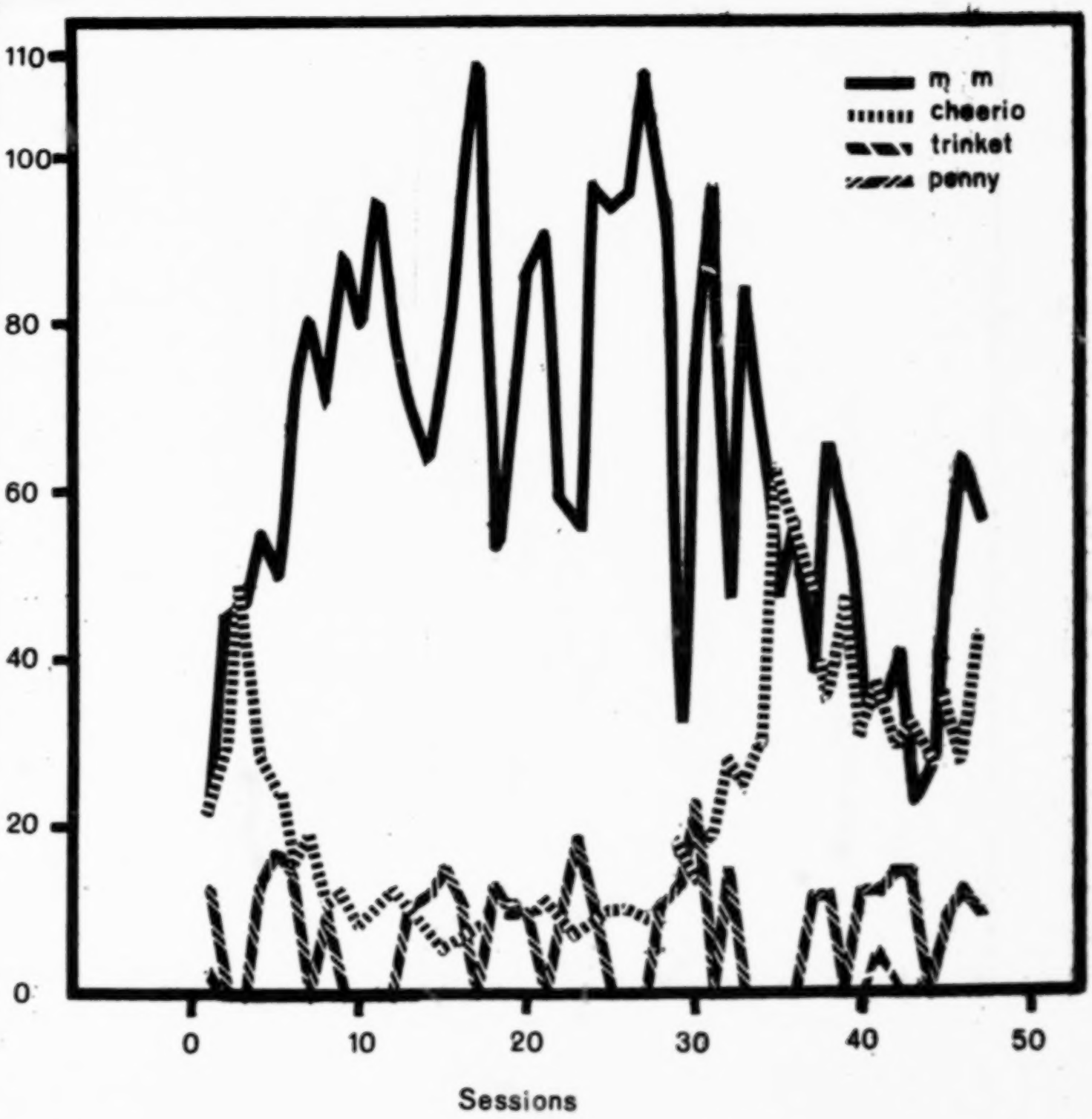


Fig. 11. Frequency of reinforcer choices per session, S P1.

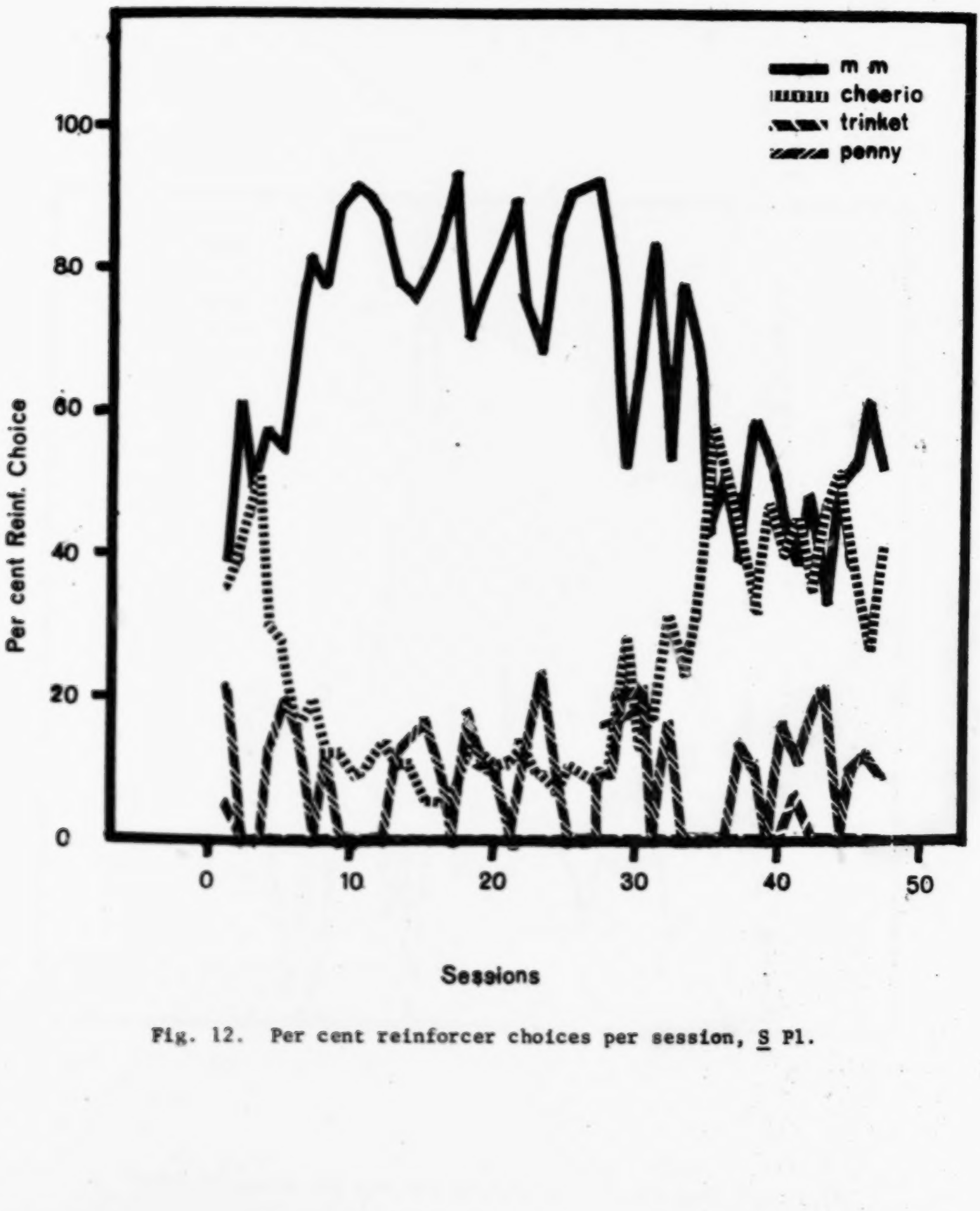


Fig. 12. Per cent reinforcer choices per session, S P1.

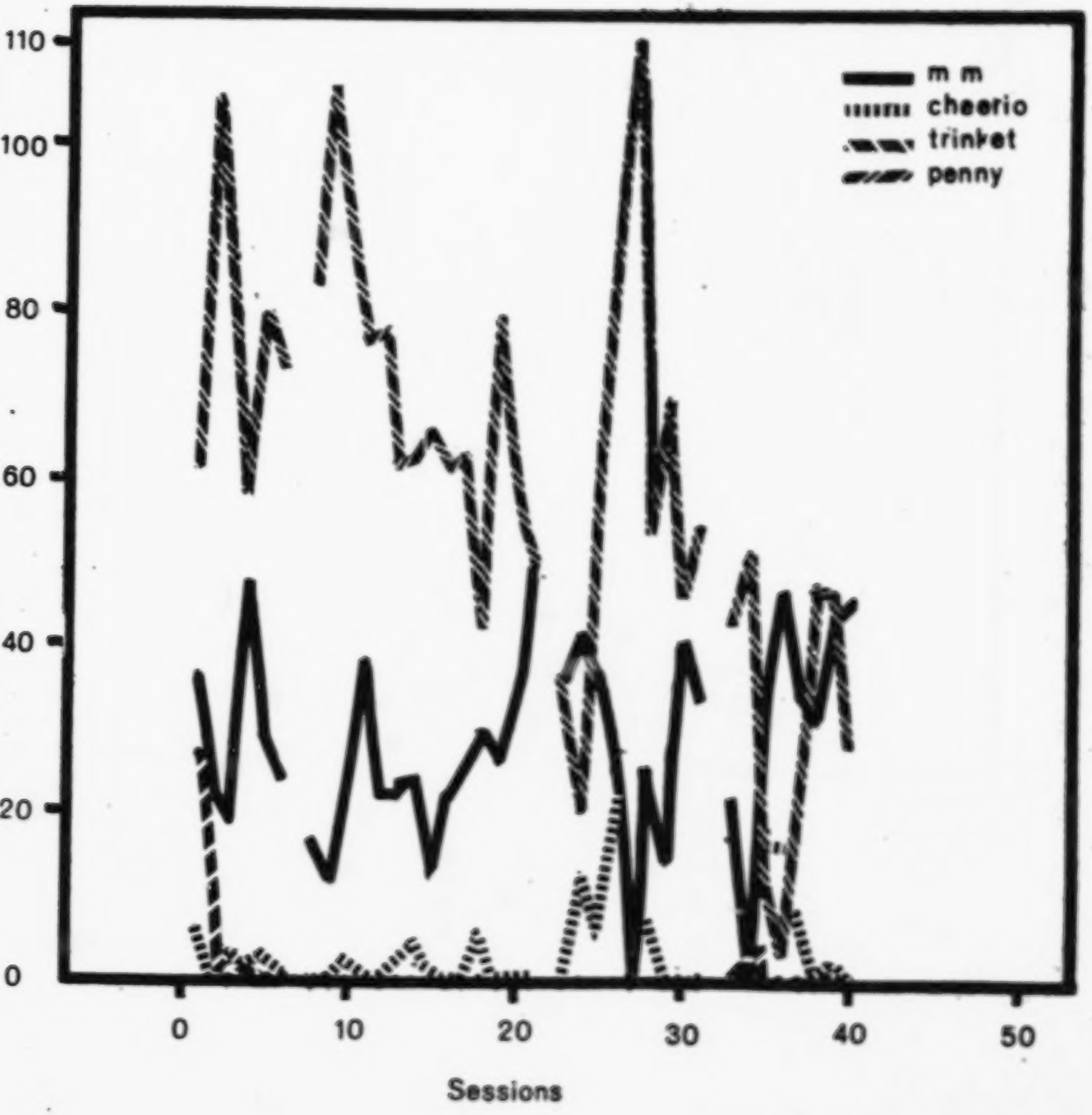


Fig. 13. Frequency of reinforcer choices per session, S W2.

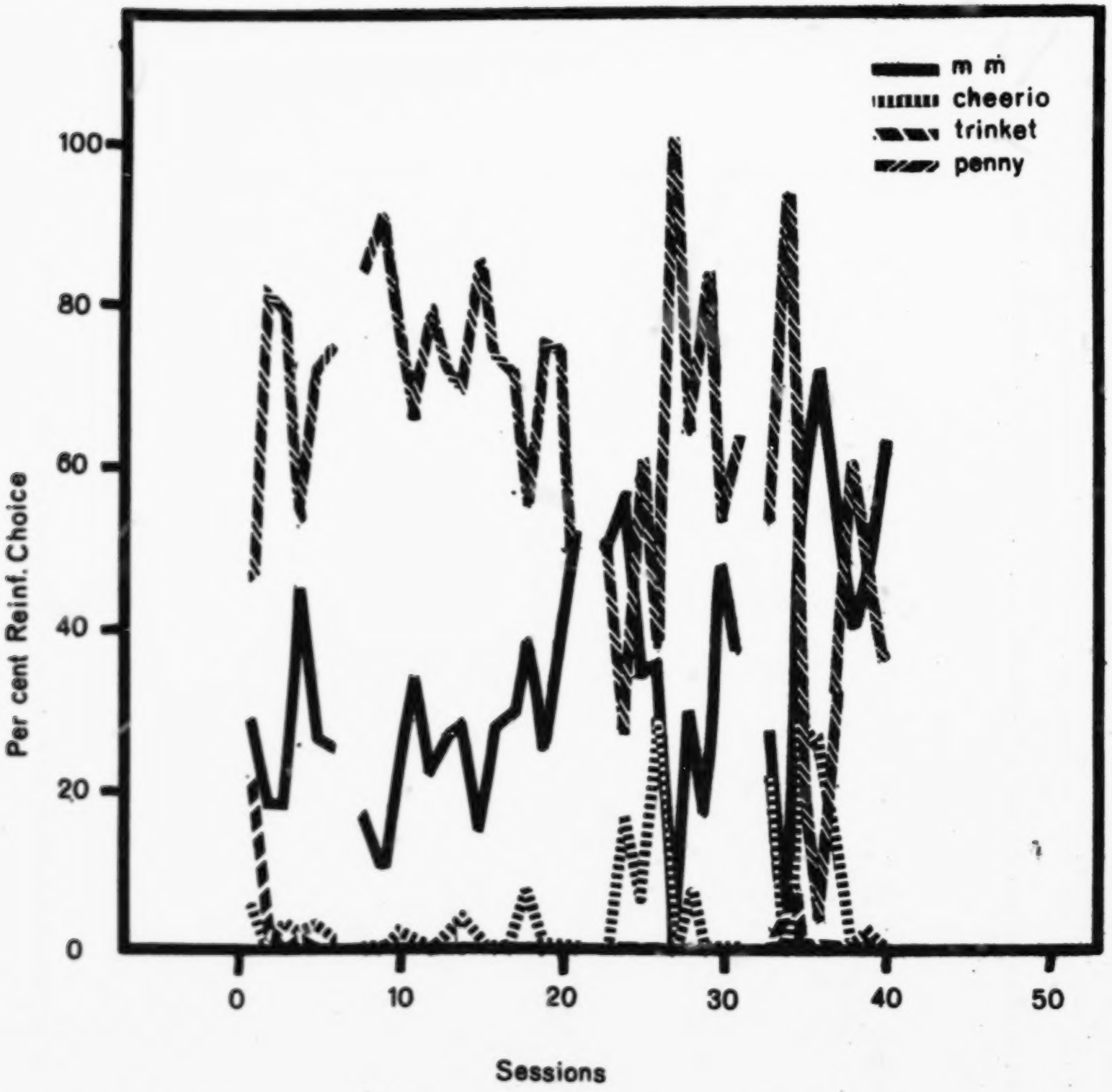


Fig. 14. Per cent reinforcer choices per session, S W2.

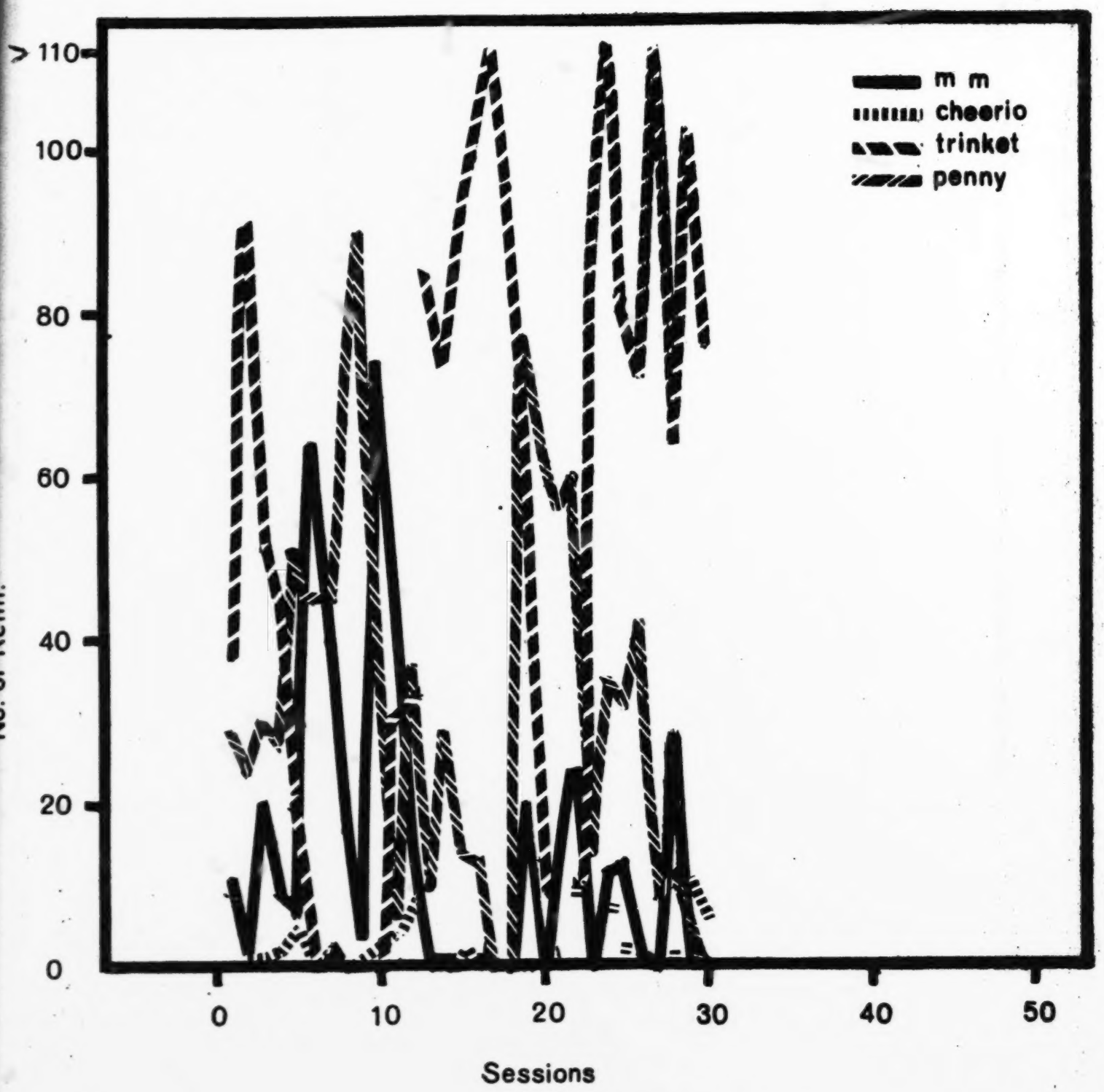


Fig. 15. Frequency of reinforcer choices per session, S G2.

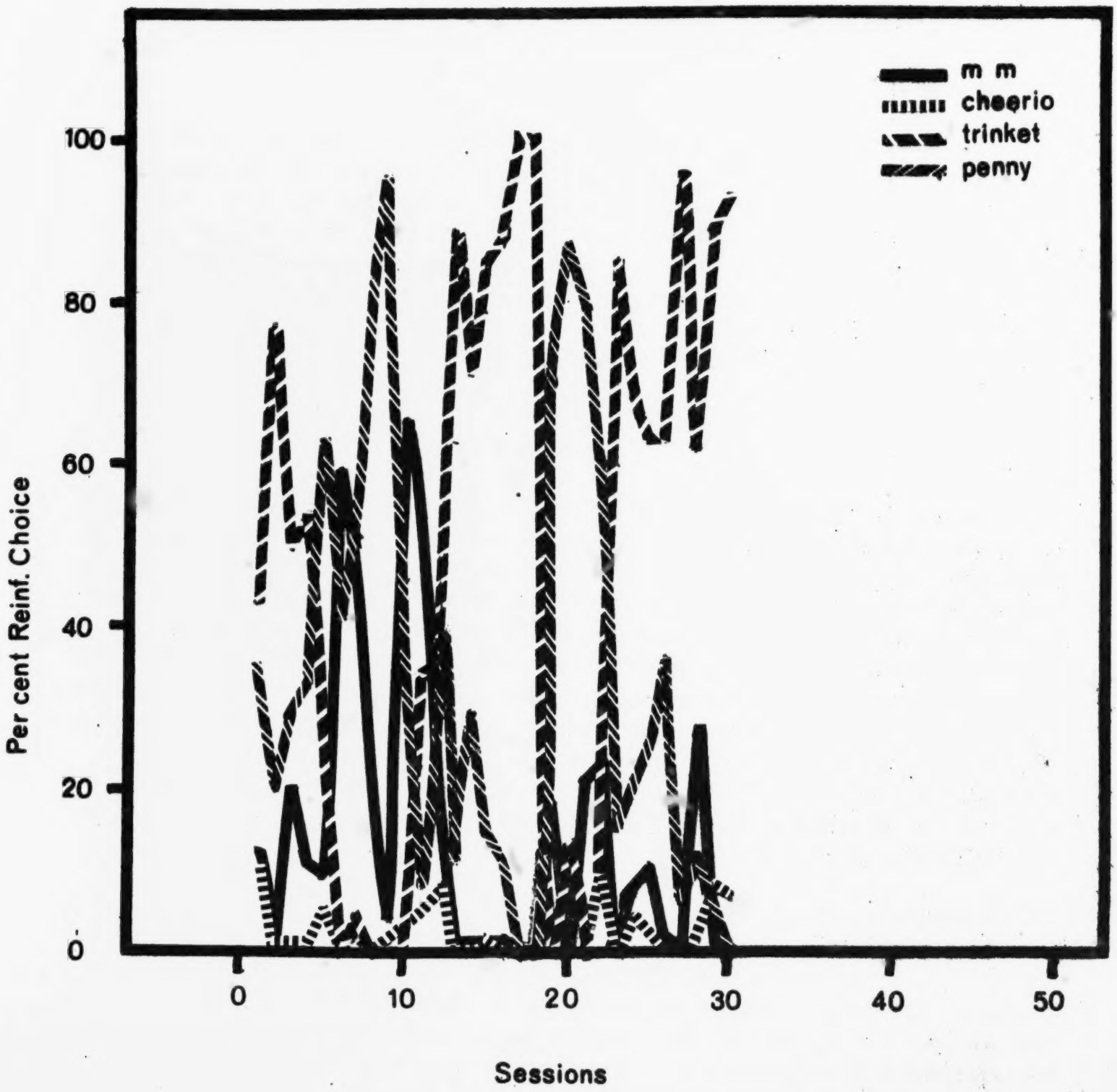


Fig. 16. Per cent reinforcer choices per session, S G2.

by a return to a high degree of variability. Generally, the behavior may be described as a consistent "preference" for a particular reinforcer, trinkets, but the variability which can be seen in the other choices preclude, at present, definitive statements about a stabilized distribution - a clear hierarchy of reinforcers.

A more extreme example may be seen in the behaviors depicted in Figures 17 and 18. Clearly, there is marked variability in the behavior from session to session. Although any one reinforcer may be followed over sessions and some regularity in its frequency of selection noted, it is not possible to observe any simple and consistent pattern which might be labelled as a stable hierarchy, and the day-to-day variability is of such a nature that additional data on this individual's behavior are required before any long-term cycles may be identified.

## DISCUSSION

The results indicate the feasability of obtaining repeated measures of reinforcer choice behavior both within sessions and over a long series of sessions, and in a situation in which individual Ss are afforded an opportunity to select from an array of reinforcers. The number and kinds of reinforcers in the array are limited only by restriction of the apparatus described to events which can be depicted graphically. Within this restriction, the possibility still exists for the inclusion of other reinforcing events, such as access to social stimuli, through the use of token reinforcers which could be exchanged for such social reinforcers. It thus appears feasible to evaluate a large number of reinforcing events for each individual, and to measure preference as a function of the number and kinds of events in the array.

A difficulty in the assessment of relative effectiveness encountered in the present study is the fact that it appears that for most Ss one reinforcer is more effective than all the others to the degree that responses primarily are made to this one reinforcer to the almost virtual exclusion of the others. Exceptions to this tend to be cases in which a second reinforcer is selected with a frequency only slightly above the 10 or 15 per cent level, and on some sort of cyclical basis. Clearly, it is not possible to make a meaningful differentiation among the relative preferences for all reinforcers in each case. Thus, for individual analysis, it would seem to be advisable to manipulate the kinds of reinforcers available and other parameters, such

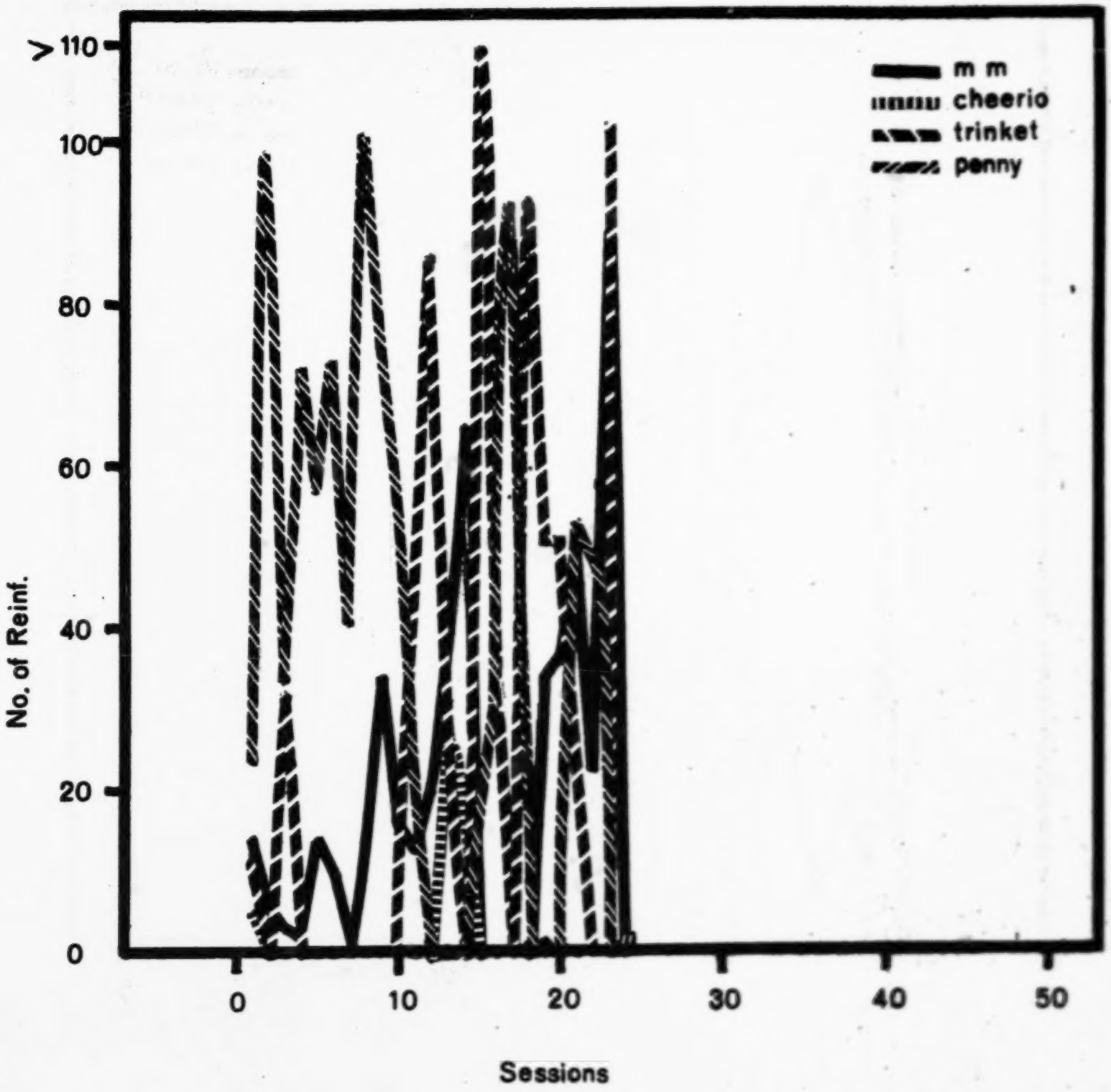


Fig. 17. Frequency of reinforcer choices per session, S P2.

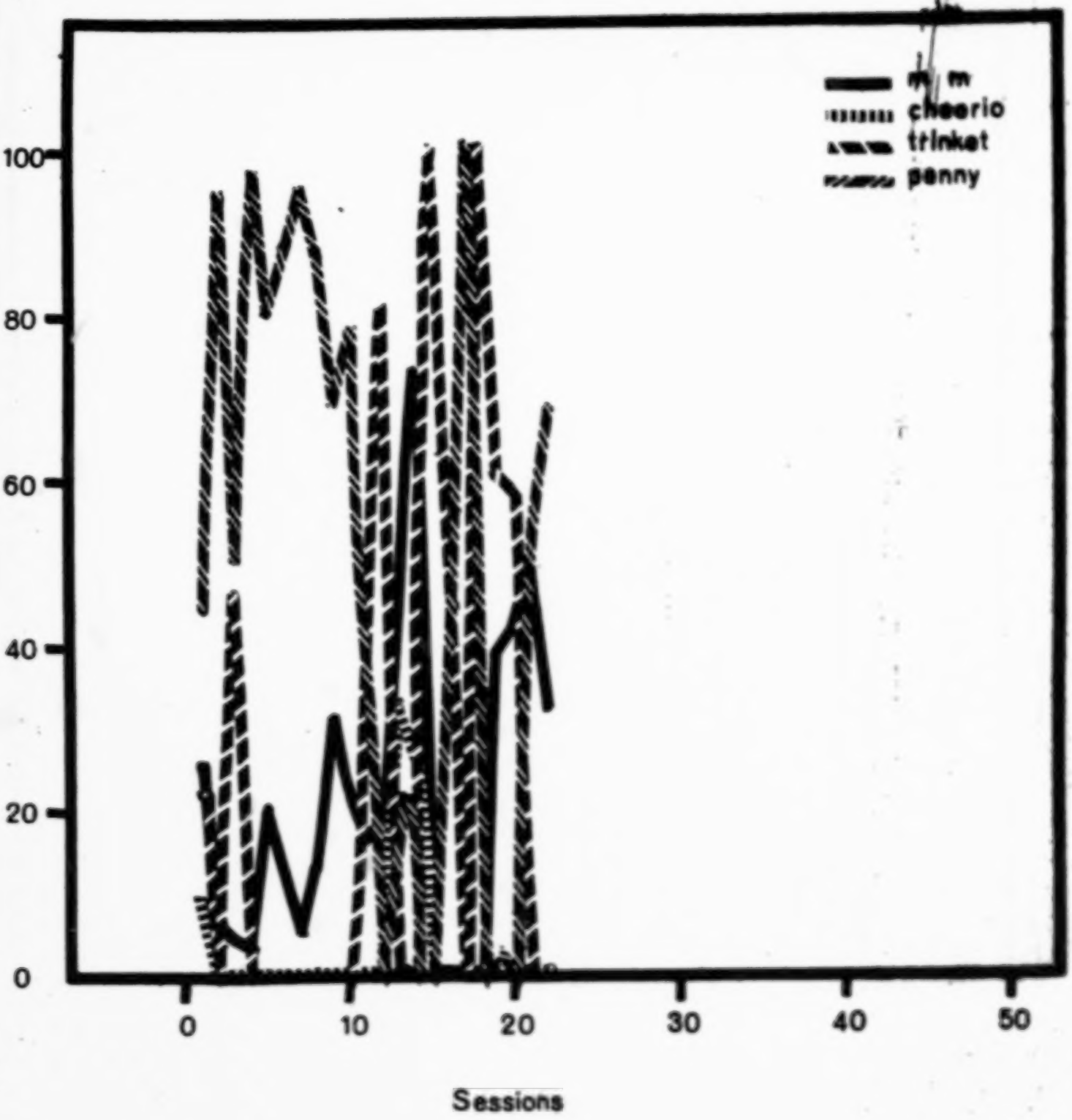


Fig. 18. Per cent reinforcer choices per session, S P2.

as response effort and the amount of reinforcement delivered, in order to establish a clearly differentiated hierarchy of reinforcing events for individual Ss.

The assessment procedure also is confounded with day-to-day variation in the number of reinforcers received per session. In a minority of cases, the total number of reinforcers received per session varies within acceptable limits. More frequently, rate either increases to the point at which the rate is limited by the characteristics of the responding organism (responses cannot be emitted at a higher rate) or those of the apparatus (programming and recording components will function no faster), or there is a steady decrease in rate over sessions, and less behavior is sampled each session.

In an attempt to control for day-to-day variation in rate, and to eliminate the possible confounding effects, measures and criteria are being developed to include within-and between-session adjustment to the individual's rate of responding. This is accomplished through repeated with-in session assessment of rate, and adjustment of the access ratio to that value which would result in the accumulation of 80 to 120 reinforcers per 30-min session. Concurrently, criteria are being developed to determine the optimal degree of change in ratio. The goal is to determine measures and criteria related to rate of response that will be continuously adjusting to the behavior of the S and which will result in highly stable rates of behavior.

It is obvious from the data collected thus far that repeated measures are essential. Assuming that the behavior of those Ss who show a high frequency of selection of a particular reinforcer is to some degree a function of the fact that a strong reinforcer is being compared with relatively weak ones, it may be the case that the stability of choice responses would not be maintained were other reinforcing events added to the array. Their behavior then would be more similar to that of Ss who show some initial variability in terms of reinforcers chosen and the frequencies with which they are chosen. In the latter instance, it is clear that no hierarchical differentiation is discernible within the first few sessions. No statement based on the frequencies with which reinforcers are selected is meaningful in the context of a greater number of sessions; predictions of reinforcer

effectiveness based on these choices have little validity in a situation in which repeated sessions are administered.

Any preference stabilization that occurs does so only after several sessions, and the number of sessions preceding stabilization varies for individual Ss. Further, the superimposed cycles of low frequency choice behavior on what might be called a high and stable preference for one reinforcer must be accounted for if behavior change as a function of the manipulation of a parameter or imposed variable is to be evaluated. In the present data, examples of both day-to-day and long-term cyclicity are evident, and appear to be the rule rather than the exception.

This sort of variability in the data is apparent only with several repeated sessions. Assessment of its degree of regularity requires extensive and unconfounded measurement, and only in determining its regularity is it possible to separate those changes which are a function of cyclic regularity and those which are a function of variable manipulation. To the extent that refinements in methodology result in increased stability of behavior, the procedure described herein will serve as a stable baseline for the analysis of the parameters of reinforcer hierarchy and the relationships between these parameters and the acquisition and maintenance of complex behaviors. The sensitivity of the baseline remains to be formally demonstrated, but pilot data suggest that it is at least sensitive to such variables as the choice ratio (number of responses required on a choice window prior to the delivery of the reinforcer), and other variables will be evaluated as the methodology further is developed.

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